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DISTRIBUTION OF EFFECTIVE TEMPERATURE RANGE UNDER CLIMATE CHANGE (IN THE EXAMPLE OF SAMARKAND REGION)

G.Kholbaev[1.2], D. Eshmirzaev[1.2], Kh. Egamberdiev[1], U.Shermukhammedov[2], M.Arzikulov[1], Sh.Yuldasheva[1]
[1] National University of Uzbekistan after named Mirzo Ulugbek, Tashkent, Uzbekistan.
[2] Hydrometeorology Research Instituti, Tashkent, Uzbekistan.

G.Kholbaev National University of Uzbekistan after named Mirzo Ulugbek, Tashkent, Uzbekistan.

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Abstract. The sum of effective air temperatures above 0.0°, 5.0°, 10.0°, 15.0°C in the vegetation period in the territory of the Samarkand region for 1991-2020 was calculated. In 2023, the area of agricultural crops in the region decreased by 50 thousand hectares compared to 2010. The maximum values of the sum of effective temperatures above 0.0°C were observed at the Samarkand station and the minimum values at the Kushrabad station. The sum of effective temperatures above 10.0°C varied from 5.0°-17.0°C in winter, 138.0°-195.0°C in spring, 119.0°-335.0°C in summer, and 78.0°-378.0°C in autumn. The highest change compared to the base climatic period (1961-1990) and the years 1971-2000 was observed in the period from 2011 to 2020.

Keywords: region, agriculture, station, vegetation period, thermal resource, air temperature exceeding 5.0°C, effective temperature.

Iqlim o‘zgarishi sharoitida samarali haroratlar yig‘indisi taqsimoti (Samarqand viloyati misolida)

Annotatsiya. 1991-2020 yillar uchun Samarqand viloyati hududida vegetatsiya darida havo haroratining 0.0° 5,0°, 10,0°, 15,0°C dan yuqori samarali haroratlar yig‘indilari hisoblandi. Viloyatning qishloq xo‘jaligi ekin maydonlari 2010 yilga nisbatan 2023 yilda 50 ming.ga. qisqargan. 0,0°C dan yuqori samarali haroratlar yig‘indisining yillaro o‘zgarishining maksimal qiymati Samarqand stansiyasida, Qo‘shrobod stansiyasida minimal qiymatlari kuzatilgan. 10,0°C dan yuqori samarali haroratlar yig‘indisi qish – 5,0°-17,0°C, bahor – 138,0°-195,0°C, yoz – 119,0°-335,0°C, kuz – 78,0°-378,0°C oraliqda o‘zgargan. Bazaviy iqlimiy davrga (1961-1990 yy.) hamda 1971-2000 yillarga nisbatan eng yuqori o‘zgarish 2011-2020 yillarda oralig‘ida o‘zgarishi aniqlandi.

Kalit so‘zlar: viloyat, qishloq xo‘jaligi, ekin maydoni, stansiya, vegetatsiya davri, termik resurs, havo haroratining 5,0°C dan o‘tishi, samarali harorat.

Распределение эффективного диапазона температур в условиях изменения климата (на примере Самаркандского региона)

Аннотация. Была рассчитана сумма эффективных температур воздуха выше 0,0°, 5,0°, 10,0°, 15,0°C в вегетационный период на территории Самаркандской области за 1991-2020 годы. В 2023 году площадь сельскохозяйственных культур в регионе сократилась на 50 тысяч гектаров по сравнению с 2010 годом. Максимальные значения суммы эффективных температур выше 0,0°C наблюдались на станции

Самарканд, а минимальные — на станции Кушрабад. Сумма эффективных температур выше 10,0°C варьировалась от 5,0°-17,0°C зимой, от 138,0°-195,0°C весной, от 119,0°-335,0°C летом и от 78,0°-378,0°C осенью. Наибольшие изменения по сравнению с базовым климатическим периодом (1961-1990 гг.) и 1971-2000 гг. наблюдались в период с 2011 по 2020 год.

Ключевые слова: регион, сельское хозяйство, станция, вегетационный период, тепловой ресурс, температура воздуха выше 5,0 °C, эффективная температура.

Introduction. In recent years, the reforms being implemented in the Samarkand region have also encompassed agricultural activities alongside other sectors under conditions of limited land and water resources, the rational organization of agricultural activities requires the introduction of new approaches to assessing available resources and using them efficiently, taking into account changes in climatic conditions.

Changes in meteorological parameters during the vegetation period of agricultural crops, as well as their analysis and assessment serve to provide agrometeorological services for agriculture in certain regions, its improvement, and thereby determine the prospects for agricultural development. For this purpose, the study of thermal resources acquires important scientific and practical significance. Currently, considerable work has been done to positively address these tasks [2, 3-4, 7, 11].

The main crops cultivated on irrigated lands are cotton, rice, and winter wheat. The radiation and thermal resources of cotton, rice, and winter wheat are presented in scientific literature [2, 3, 4].

In the general zoning section of agroclimatology, zoning is primarily based on the duration of the overall vegetation period, in accordance with climatic parameters and their spatial distribution across regions. When determining the beginning and end of the vegetation period, it is divided into districts based on the distribution of climatic magnitudes such as the duration between the date when air temperature rises above a certain level in spring and decreases in autumn, and the sums of active and effective temperatures [2, 4, 11-14, 16].

In recent decades, taking into account climate change and the replacement of agricultural crops with regional varieties, identifying and assessing the vegetation period and thermal resources for this period has become an urgent task.

Taking into account this need, the assessment of the thermal and climatic resources of the vegetation period (the sum of effective air temperatures in autumn and spring at 0.0°, 5.0°, 10.0°, 15.0°C) during the cultivation of agricultural plants in the existing sown areas of the Samarkand region was defined as the goal of the work, and the analysis of thermal and climatic resources in the region as the task of the work.

The vegetation period of agricultural crops grown in the sown areas of the region is the **object** of the research, the determination of the distribution of effective temperatures at different levels, and the issue of climate change is the **subject** of the work.

Initial data and research methods. Data from the Statistics Committee and the Uzhydromet archival database were used in the research. Calculations of the sum of effective temperatures above 0.0°, 5.0°, 10.0°, 15.0°C were carried out. The calculations were performed based on the methods presented in the sources [1].

Main results and their discussion. The growth of the population of the Samarkand region and the expansion of the area of cities require the allocation of a certain part of the irrigated lands of the districts for public and state needs (Fig. 1).

If we pay attention to Figure 1, the area of agricultural land in the region decreased by 50 thousand hectares in 2023, compared to 2010, the largest decrease by districts was 54.8% (Samarkand), 45.7% (Urgut), 20.1-21.0% (Pakhtachi, Poyaryk, Nurabad), in the remaining districts 9.2-14.5% (Taylak, Kattakurgan, Zhambay, Bulungur, Ishtikhan).

As is known, heat is the main agrometeorological, agroclimatic, and climatic factor in the growth of agricultural crops, the accumulation of productivity elements, and the formation of yields. Plants' demand for moisture is met through irrigation. When assessing thermal resources that determine the heat supply of plants, indicators of the sum of effective temperatures during a period when the average air temperature is above certain levels are used.

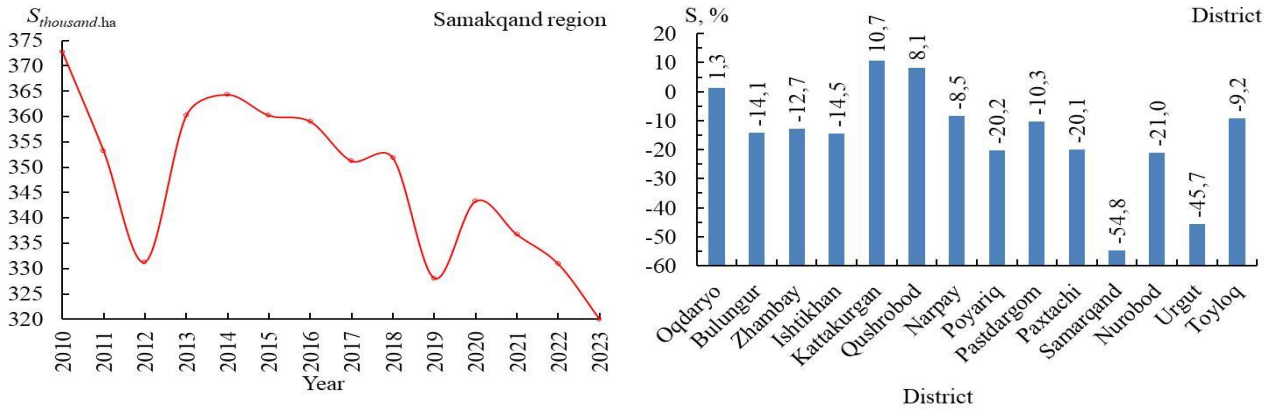


Figure 1. Agricultural crops of Samarkand region and its districts
Dynamics of annual changes in sown area

The region differs from each other in its natural-geographical and soil-climatic conditions. However, in turn, the territories of the districts of the region do not consist of districts with the same natural conditions. Therefore, in each district, the selection of plant varieties based on their suitability for the external environment is widely practiced. In this case, the optimal planting dates for agricultural crops are determined taking into account the air temperature sufficient for the development of plant species.

As a result of the conducted research, comparative work was carried out on the sum of effective air temperatures above 0.0°, 5.0°, 10.0°, 15.0°C based on data from the last 1991-2020.

We will consider the interannual change in the sum of effective temperatures accumulated by the last ten days of winter, spring, summer, and autumn at meteorological stations located in the Samarkand region (Fig. 2).

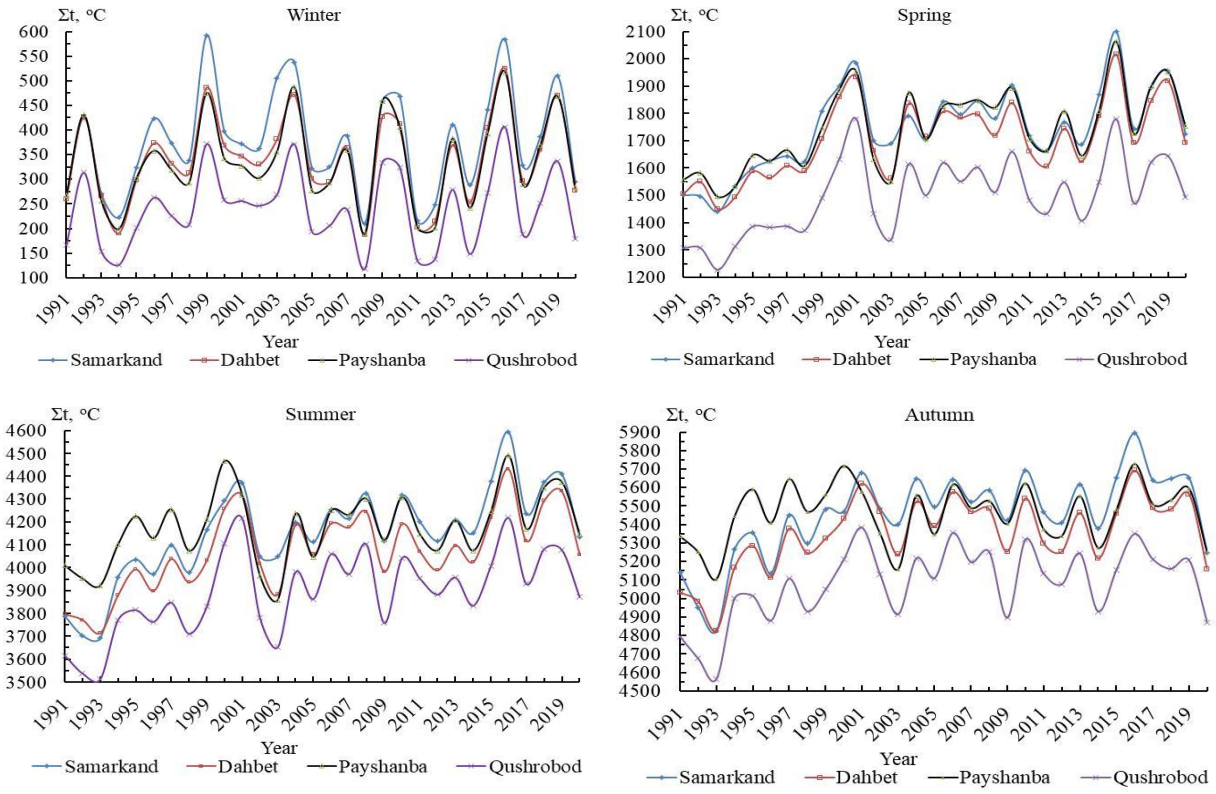


Figure 2. Interannual change in the sum of effective temperatures above 0.0°C at agrometeorological stations

As can be seen from Figure 2, the interannual change in the sum of effective temperatures above 0.0°C was the following interval:

- in the winter months 1999, 2004, 2016 years the maximum value was observed, the minimum value was noted in 1994, 2008, 2011, 2012, 2014 years;
- maximum in the month of spring in 2000, 2016, minimum in 1993, 2003;
- in the summer months, the maximum values were in 2000, 2016, and the minimum in 1993, 2003;

In the autumn months, the maximum values were recorded in 2016, and the minimum values in 1993.

In general, the maximum values of the annual change in the sum of effective temperatures above 0.0°C were observed at the Samarkand station and the minimum values at the Kushrabad station.

It is known that a certain set of effective temperatures is necessary for the growth, development, and accumulation of elements of productivity of agricultural crops.

Tables 1-2 show the average values of the sum of effective temperatures accumulated by the last ten days of winter, spring, summer, and autumn in 1991-1995, 1996-2000, 2001-2005, 2006-2010, 2011-2015, 2016-2020, as well as the difference in effective temperatures accumulated in 2016-2020 compared to 1991-1995.

Table 1

Sum of effective temperatures above 0.0°C

Station	Five-year Plan						Δ (1991-1995) - (2016-2020) yy..
	1991-1995 yy.	1996-2000 yy.	2001-2005 yy.	2006-2010 yy.	2011-2015 yy.	2016-2020 yy.	
Winter (XII-II)							
Samarkand	302	425	420	370	321	416	114
Dahbet	289	375	366	337	289	386	97
Thursday	292	358	350	341	285	386	94
Koshrabad	192	265	267	244	194	272	80
Spring (III-V)							
Samarkand	1514	1720	1774	1833	1741	1879	365
Dahbet	1517	1666	1741	1789	1686	1833	316
Thursday	1563	1707	1743	1845	1727	1879	316
Koshrabad	1308	1452	1533	1589	1484	1601	293
Summer (VI-VIII)							
Samarkand	3835	4101	4156	4245	4211	4344	509
Dahbet	3831	4032	4092	4157	4080	4246	415
Thursday	4042	4227	4085	4242	4150	4307	265
Koshrabad	3650	3851	3898	3986	3926	4035	385
Autumn (IX-XI)							
Samarkand	5108	5368	5542	5574	5506	5613	505
Dahbet	5059	5299	5449	5466	5339	5477	418
Thursday	5346	5561	5399	5533	5405	5523	177
Koshrabad	4810	5036	5152	5204	5108	5160	350

As can be seen from Table 1, the distribution of the sum of average effective temperatures by seasons in 2016-2020 compared to 1991-1995 is as follows: winter - from 80.0°C (Kushrabat) to 114.0°C (Samarkand), spring - from 293.0°C (Kushrabat) to 365.0°C (Samarkand), summer - from 265.0°C (Payshanba) to 509.0°C (Samarkand), autumn - from 177.0°C (Payshanba) to 505.0°C (Samarkand). In general, the observation of high temperature values at the Samarkand station was caused by the expansion of the city territory or the fact that the station remained inside the city, due to the relocation of the Kattakurgan station to Payshanba in 2002, i.e., the change in the station's location (from Kattakurgan (485 h.t.p.) to Payshanba (450 h.t.p.).

Table 2

Sum of effective temperatures above 10.0°C

Station	Five-year Plan						(1991-1995) - (2016-2020)
	1991-1995 pp.	1996-2000 pp.	2001-2005.	2006-2010	2011-2015.	2016-2020	
Winter (XII-II)							
Samarkand	10	20	22	17	16	27	17
Dahbet	6	10	11	11	9	17	11
Payshanba	2	6.	5	6	5	13	11
Koshrabad	1	2	1	1	1	6	5
Spring (III-V)							
Samarkand	428	513	538	612	612	623	195
Dahbet	427	493	543	587	580	597	170
Payshanba	456	536	548	626	612	627	171
Koshrabad	350	423	454	493	493	488	138
Summer (VI-VIII)							
Samarkand	1833	1976	2000	2104	2162	2168	335
Dahbet	1820	1941	1974	2034	2056	2091	271
Payshanba	2016	2138	1969	2104	2115	2135	119
Koshrabad	1774	1904	1899	1971	2015	2001	227
Autumn (IX-XI)							
Samarkand	2285	2457	2543	2611	2675	2663	378
Dahbet	2238	2413	2490	2518	2533	2550	312
Payshanba	2497	2673	2444	2572	2576	2575	78
Koshrabad	2156	2337	2350	2403	2452	2396	240

As can be seen from Table 2, the distribution of the sum of average effective temperatures by seasons in 2016-2020 compared to 1991-1995 is as follows: winter - from 5.0°C (Kushrabat) to 17.0°C (Samarkand), spring - from 138.0°C (Kushrabat) to 195.0°C (Samarkand), summer - from 119.0°C (Payshanba) to 335.0°C (Samarkand), autumn - from 78.0°C (Payshanba) to 378.0°C (Samarkand).

Figure 3 shows the differences in the sum of effective temperatures above 10.0°C during the growing season for the years 1991-1995, 1996-2000, 2001-2005, 2006-2010, 2011-2015, 2016-2020.

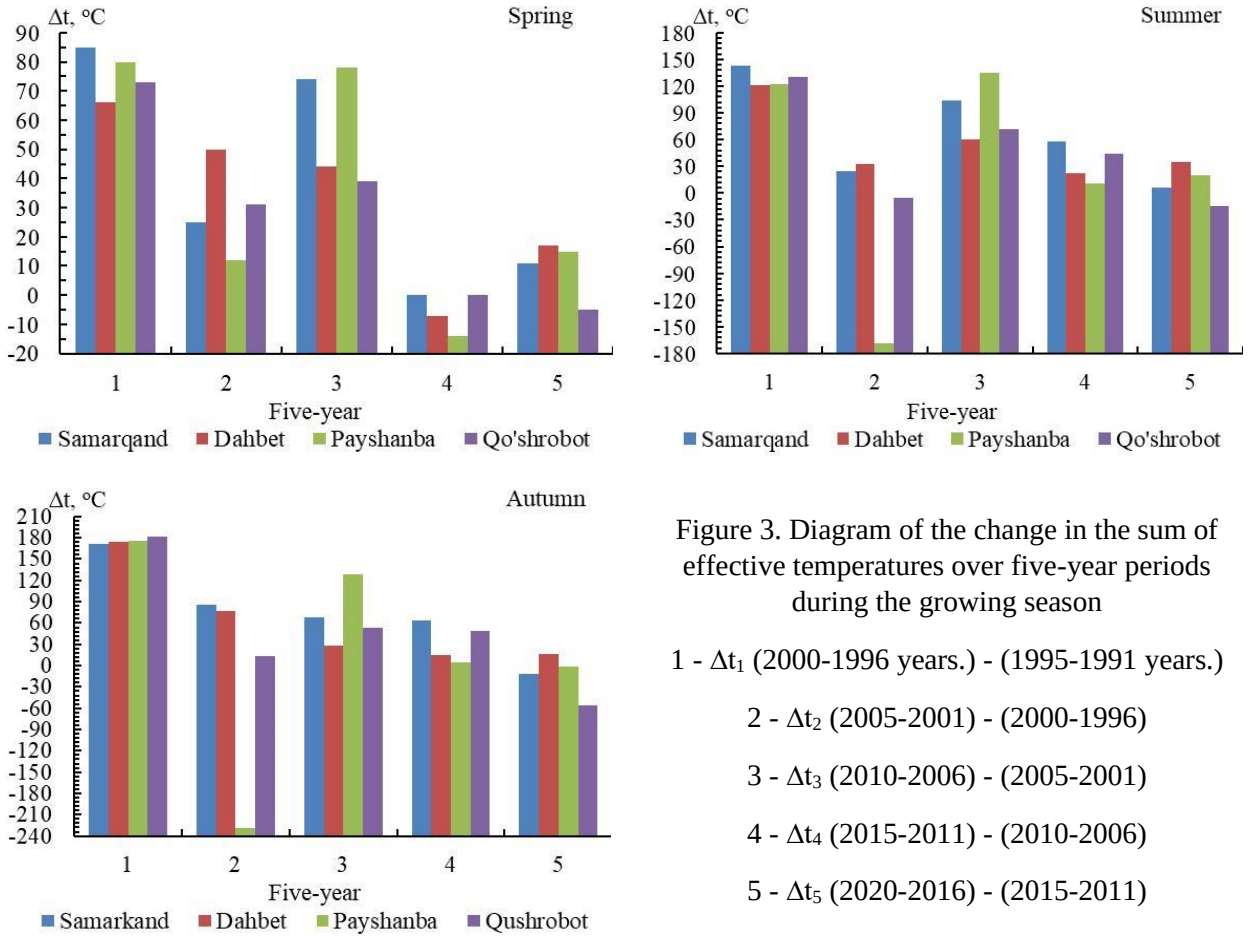


Figure 3. Diagram of the change in the sum of effective temperatures over five-year periods during the growing season

1 - Δt_1 (2000-1996 years.) - (1995-1991 years.)

2 - Δt_2 (2005-2001) - (2000-1996)

3 - Δt_3 (2010-2006) - (2005-2001)

4 - Δt_4 (2015-2011) - (2010-2006)

5 - Δt_5 (2020-2016) - (2015-2011)

As can be seen from Figure 3, ***in the spring*** five-year periods - Δt_1, Δt_2, Δt_3 and Δt_5 the sum of effective temperatures had a positive value, while in the Δt_4 five-year periods in Samarkand and Koshrabad no changes were noted, in Dahbet and Payshanba it had a negative value, that is, a decrease in the sum of effective temperatures was observed compared to the previous five-year periods. A decrease in the sum of effective temperatures was observed in the following five-year periods: ***In summer*** - Samarkand, Dahbet - Δt_1-Δt_5 in the five-year periods, On Thursday Δt_1, Δt_3-Δt_5 in the five-year periods, in Qushrobod $_{\Delta t1,}$ Δt_3-Δt_4 in the five-year periods if there is an increase in the sum of effective temperatures, < ***In autumn*** - In Dahbet - Δt_1-Δt_5, in Samarkand and Qushrobot Δt_1-Δt_4, in Payshanba Δt_1, Δt_3-Δt_4, In Samarkand, Payshanba and Qushrobot Δt_5 we can see a decrease in A sharp change in temperature difference at Thursday station was observed in 2002-2005 when the average air temperature was low.

The Earth's climate has changed over the centuries. As a result of such changes, the climate of any geographical region has changed to colder or warmer, more humid or drier. Rapid changes in the duration and intensity of climatic extremes (cold periods, heat and drought, heavy rains, hail, dust storms, floods, storms) have been observed.

Climate largely determines the productivity of cultivated agricultural crops and livestock. Therefore, in order to properly utilize the climatic potential of the regions, it is first necessary to study the climate, determine its significance in agriculture, and know ways to reduce the damage caused by adverse weather conditions.

Climatic standards have two main purposes: they serve as an indicator of conditions corresponding to the current climatic trend in a given area, and the control point allows for the comparison of climatic conditions in a given area (or region) over a given time [8]. Research on these

problems was conducted by the UNODC [3] and [5, 6, 9, 10, 15], and by researchers on climate change [5, 6, 9-11, 15].

Based on the analysis of the above-mentioned researchers, as an example, the data of the sum of effective temperatures above 5.0°, 10.0°, and 15.0°C for 1991-2020 were compared with the data of 1961-1990 and 1971-2000 years [7] (Table 3).

Table 3

Comparison of the sum of effective temperatures

Station, period, years	5.0°			10.0°			15.0°		
	Σt	At		Σt	At		Σt	At	
		*	**		*	**		*	**
Samarkand									
1961-1990*	3314			2160			1180		
1971-2000 [9]	3431			2294			1322		
1991-2000	3423	109		2312	152		1355	175	
2001-2010	3679	365	248	2513	353	219	1476	296	154
2011-2020	3772	458	341	2621	461	327	1595	415	273
1991-2020	3625	311		2482	322		1479	299	

As can be seen from Table 3, the changes in the sum of effective temperatures in 1991-2000, 2001-2010, 2011-2020, and 1991-2020 are as follows:

basic climate period (1961-1990 yy.):

- 1991-2000: 5.0°C - 109.0°C, 10.0°C - 152.0°C, 15.0°C - 175.0°C;
- 2001-2010: 5.0°C - 365.0°C, 10.0°C - 353.0°C, 15.0°C - 296.0°C;
- In 2011-2020, effective temperatures above 5.0°C were 458.0°C, from 10.0°C - 461.0°C, 15.0°C - 415.0°C,
- 1991-2020. 5.0°C - 311.0°C, 10.0°C - 322.0°C, 15.0°C - 299.0°C;

The highest change was observed in 2011-2020.

Compared to 1971-2000, the changes are as follows:

- 2001-2010: 5.0°C - 248.0°C, from 10.0°C - 219.0°C, 15.0°C - 154.0°C;
- 2011-2020: 5.0°C - 341.0°C, 10.0°C - 327.0°C, 15.0°C - 273.0°C.

The biggest changes here were also observed in 2011-2020.

As can be seen, an increase in the sum of temperatures in the regions leads to a change in the vegetation period and an increase in dangerous meteorological phenomena.

Conclusion. The area of agricultural crops in the region decreased by 50 thousand hectares in 2023 compared to 2010. The maximum values of the sum of effective temperatures above 0.0°C were observed at the Samarkand station and the minimum values at the Kushrabad station. The sum of effective temperatures above 10.0°C varied from 5.0°-17.0°C in winter, 138.0°-195.0°C in spring, 119.0°-335.0°C in summer, and 78.0°-378.0°C in autumn. The highest change compared to the base climatic period (1961-1990) and the years 1971-2000 was observed in the period from 2011 to 2020.

The reason for the observation of high temperatures at the Samarkand station was the expansion of the city territory or the fact that the station remained within the city limits, due to the relocation of the Kattakurgan station to Payshanba in 2002, i.e., the change in the station's location (from Kattakurgan (485 p.m.f.) to Payshanba (450 p.m.f.).

The results of the conducted research showed that the distribution of the sum of effective air temperatures above 5.0°, 10.0°, and 15.0°C in autumn and spring in the territory of the Samarkand region corresponds to zonal patterns of geographical latitude and altitude.

The distribution of the sum of the highest effective air temperatures of 5.0°, 10.0°, and 15.0°C in the territory of the region can be used in practice by specialists working in this area. Also, it is advisable to use the results obtained in the future in the preparation of the monograph-reference "Agroclimatic Resources of Samarkand Region," which fully covers radiation and thermal resources in the agricultural sector.

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